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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 : F21V 8/00 — A1

(11) International Publication Number: WO 00/04322

(43) International Publication Date: 27 January 2000 (27.01.00)

(21) International Application Number: PCT/US99/15823

(22) International Filing Date: 14 July 1999 (14.07.99)

(30) Priority Data:
10/203476 17 July 1998 (17.07.98) JP

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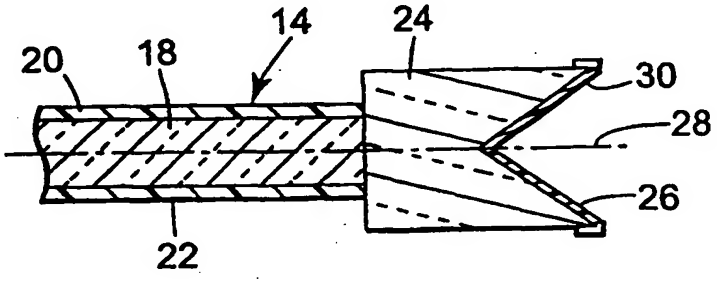
(81) Designated States: JP, KR, US, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: DISPLAY DEVICE AND OPTICAL FIBERS USED FOR THE SAME

(57) Abstract

A display device (10) is constructed to have a light source (12), at least one optical fiber (14) in which light from said light source (12) is introduced at one end and are discharged from the other end, a light diverter (34) that is arranged at said other end of said optical fiber (14) and diverts light, and a display body (32) that is irradiated by the light from said light diverter (24).



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DISPLAY DEVICE AND OPTICAL FIBERS USED FOR THE SAME

Technical Field

This invention relates to a display device, and optical fibers of end-discharging type which are capable of discharging lights from an end part which are used for the same.

Background

An in-water illumination that is generally impossible by a light source such as a fluorescent lamp or a discharge tube represented with a neon tube has been recently accomplished through an arrangement of a light source away from an irradiated-object. When this is described in further details, optical fibers are arranged between a light source and an irradiated-object in this form of illumination. The optical fibers are generally equipped with a core at the center and a clad that shows lower refractive index than that of the core and is arranged around said center part; and they are capable of transmitting lights which enter from end of the fibers to the other end.

Optical fibers may be of a side-discharging type that is disclosed in the USA patents 4,422,719 specification and Japanese Patent Application Kokai Sho 60[1985]-118806 publication; and they are designed to enable light to exit from said side-planes to illuminate over a fairly wide region.

On the one hand, optical fibers of end-discharging type which are designed to introduce light AT one end and to discharge it from the other end are also well known. The optical fibers of this type generally show a higher luminance compared to that of the side-discharging type. In addition, optical fibers of said end-discharging type to which one end is attached to a diverging means that diverts light, for instance, a diversion lens, are also known. Such fibers are used, for instance, to provide a wide angle illumination in water fountains.

In addition, the optical fibers of end-discharging type show a beneficial point that there is no need for a disfigurement in accordance with the shape of an irradiated-object; and for instance, it is utilized for a display device having a display body such as internal illuminated billboards that are installed on high-rise buildings and the like.

Summary of the Invention

In general, irradiation of light on a display body is required to be uniform in order to secure visibility. However, when basic end-discharging optical fibers are used, they illuminate light only over a limited range. In order to allow said optical fibers to illuminate a display body in a substantially uniform manner, they must be arranged closely. In particular, in the case of a complex shape of a display body such as letters or characters, close arrangement of optical fibers becomes severe. In addition, there may be such display body that cannot be illuminated uniformly even when optical fibers are arranged closely.

Therefore this invention offers a display device that is capable of controlling a close arrangement of optical fibers, and optical fibers of end-discharging type used for the same.

This invention was completed to solve the above-explained subjects; and it offers a display device that is equipped with a light source; at the least one optical fiber in which light from said light source is introduced at one end and exits from the other end, and a light diversion means that is arranged at said other end of said optical fiber, and diverts lights, and a display body that is irradiated with lights from said light diversion means.

In addition, this invention offers optical fibers having the characteristics of being optical fibers in which light is introduced at one end and is discharged from the other end, and are equipped with a light diversion means that is arranged at said other end and diverts lights, and a light diffusion means that is arranged at said light diversion means.

Brief Description of the Drawings

Figure 1 shows a cross-sectional view of one implementation format of this invention's display device that uses optical fiber of end-discharging type;

Figure 2 shows a cross-sectional view of one implementation format of this invention's optical fiber of end-discharging type;

Figure 3 shows a cross-sectional view of an example that uses reflective member in this invention's display device;

Figure 4 shows a frontal view of front plane of internal illumination type bill board that indicates positions where luminance of the example is measured; and

Figure 5 shows luminance distribution diagram that indicates results of luminance measurement of the examples with relationship of measured position and relative luminance.

Detailed Description

This invention is explained below based on preferred implementation formats. Incidentally, identical or equivalent portions which are illustrated in the Figures bear identical Numerals.

Figure 1 shows a schematic cross-sectional view of display device (10) that is in accordance with this invention. This display device (10) is basically designed to illuminate inside of a billboard (16) that is of an internal illumination type as a display body with light from a light source (12) that includes discharge tube such as a metal halide lamp through an optical fiber (14) of end-discharging type. In further detail, one end of the optical fiber (14) is connected to the light source (12). At this time, it is all right to arrange said light source (12) at a position that eases replacement of a discharge tube. In the Figure, (22) illustrates the main body of optical fiber; and (24) illustrates a diffusion lens. In addition, although it is not illustrated in the Figure, it is all right to arrange a color

filter that can be switched on/off between said light source (12) and optical fiber (14) to illuminate plural number of visible rays as needed.

Then, when this end-discharging type optical fiber (14) is explained in reference with the Figure 2, this optical fiber (14) is generally equipped with an optical fiber main body (22) comprising a core (18) at its center part and clad (20) that shows lower refractive index than that of the core at surrounding part of said core.

The core (18) is designed to transmit light from its one end that is connected to the light source (12) to the other end; and it generally shows refractive index of 1.4 ~ 2.0. This type of core is generally formed faithfully out of not only optical glass but also light-transmitting materials such as quartz glass or polymer. As explained above, although light-transmitting materials are of solid forms, it should not be limited to these; and it may be of liquid form such as silicone gel and the like. In this case, the core is sealed in a flexible tube made of , for instance, resin.

The clad (20) shows lower refractive index than that of the core (18) as explained in the "Background"; and it is capable of confining light which passes through the core (18). More preferably, such clad (20) is formed of a light-transmitting resin such as fluorine group resin to show about 1.3 ~ 1.4 refractive index. However, clad material to be not limited to above-explained resin is easily conceivable by the person skilled in this art.

According to the display device (10) of this implementation format, a diverging lens (24) that is a light diversion measure is attached at other end part of the optical fiber main body (22). This type of diversion lens (24) is capable of expanding irradiation range of the lights by discharging through diffusing lights from that other end part toward outside. And therefore, it is possible to reduce quantity of optical fibers which should be used for uniform light irradiation on a display body to enable to relieve close arrangement. The diversion lens (24) basically has a concave ( ) plane (26) of which thickness of surrounding edge part is greater than its center part to enable to diffuse lights through refraction. The concave ( ) plane (26) of this diversion lens (24) is preferable when it

shows conical plane, spherical plane, or elliptical curved plane that is rotary symmetrical to its center axis line (28). This is because when optical fiber main body is attached to the diversion lens having above-explained concave ( ) plane (26) in such manner that it would be on the same axis to that rotary symmetrical axis, it is possible to diffuse and discharge lights which are symmetrical to that axis from the diversion lens. In particular, it is preferable when said diversion lens of which concave ( ) plane is of either spherical plane or conical plane illustrated in the Figure from the standpoint of easy workmanship.

According to this implementation format, a light diffusion layer (30) that includes particles which scatter lights not illustrated in the Figure as a light diffusion measure is preferably arranged on the concave ( ) plane (26). In this case, it is possible to further reduce quantity of to-be used optical fibers by enabling a better uniform irradiation through diffusion and transmission of lights in isotropic manner. In addition, diffusion and transmission of lights by the light diffusion layer (30) can supplement precision of workmanship even in a case of lights with uneven luminance which are discharged from the diversion lens that often has curved plane with less precision due to difficult workmanship.

It is preferable when said light scattering particles show average diameter of 0.1 ~ 1.0 μm and are capable of scattering the visible lights in isotropic manner. In addition, it is preferable when said light scattering particles are formed of such materials showing 1.6 ~ 3.2 index of refractivity as, for instance, titanium oxide (TiO_2), cadmium sulfide (CdS), cadmium selenide (CdSe), zinc (Zn), aluminium (Al), lead sulfate ($PbSO_4$), lead chromate ($PbCrO_4$), lead white ($2PbCO_3.Pb(OH)_2$), zinc oxide (ZnO), basic sulfate ($PbO.2PbSO_4$), zinc sulfide (ZnS), lead titanate ($PbTiO_3$), or zirconium oxide (ZrO_2). In addition, the light diffusion layer (30) illustrated in this Figure may be arranged at surrounding edge part of the concave ( ) plane of the diversion lens as well.

When display device (10) is constructed in above-explained manner and lights are introduced to one end part of the optical fiber main body (22) by using said light source (12), lights moves toward the other end part while showing a total reflection within the

core (18) and reach said diversion lens (24). When lights reach diversion lens (24), they reach said light diffusion layer (30) while diverging by the refraction [caused by the diverging lens]. In addition, lights exit outside of the optical fiber (14) while they are scattered in isotropic manner by the light diffusion particles within the light diffusion layer (30) to enable to uniformly illuminate over a wide range of bill board (16) of internal illumination type. And therefore, it is possible to reduce quantity of optical fibers which are to be used to provide uniform lights on a display body to relax close arrangement.

This invention was explained above with implementation format; and this invention should not be limited to this. It is all right to use a display body to which lights are illuminated from a back plane in the place of internal illumination type bill board that is designed to directly irradiate lights from inside.

In addition, light diversion measure should not be limited to above-explained diversion lens; and a prism or reflective member may be used. As illustrated in the Figure 3 in particular, when a reflective member (32) is applied to a bill board of internal illumination type as a display body that is equipped with a box (17) having a open light fiber main body induction part (15) and a display sheet (19), the reflective member (32) is made to cover entirety of other end part of the light fiber main body by having a gap with a bottom plane of the box (17) through spacers (34a), and (34b). It is also possible to allow that other end part to be partially covered with the reflective member (32). When lights exit from the other end part of the light fiber main body (22) that is covered with above-explained reflective member (32), they are reflected by reflective member (32) and leak out while diverging at surrounding edge part of the reflective member (32) to enable a uniform irradiation on the display body. In addition, it is preferable that this reflective member (32) is capable of transmitting part of the lights from the lifer fiber main body (22). This is because reflective member (32) enables more uniform irradiation as the lights are made to leak in isotropic manner.

[EXAMPLES]

This invention is explained below with examples; and it goes without saying that this invention should not be limited by these.

EXAMPLE 1

An acryl made columnar body showing 20 mm diameter and 30 mm height was prepared first in order to prepare a diversion lens. Then, rotary symmetrical conical plane (concave ( ) plane) was formed on this columnar body through cutting and shaving work to prepare a diversion lens. At this time, angle formed by rotary axis of conical plane and base line is set to be 60°. Then, this diversion lens is attached to one end part of light fiber LF120 (optical fiber main body) made by Sumitomo 3M Co. showing 14 mm diameter and 80 cm length to prepare an optical fiber of end-discharging type.

EXAMPLE 2

An optical fiber was prepared in the same manner as explained in the example 1 by spraying a spray agent for hobby that includes titanium dioxide and made by Nippe Home Products Co. on a conical plane of diversion lens to form a light diffusion layer.

Then, evaluation on display device using optical fibers prepared in the example 1 and example 2 was conducted. That evaluation was conducted based on relative luminance against maximum luminance of the optical fibers. Measurement on absolute luminance was conducted by using a luminance measuring device (CS-100) made by Minolta Co. At this time, metal halide lamp)LBM 130H) made by Sumitomo 3M Co. that can be easily obtained was attached to other end part of the optical fiber as a light source. In addition, as illustrated in the Figure 4, one end part of the optical fiber was attached to a bill board of internal illumination type to measure absolute luminance at every 50 mm from the attachment position (this is referred to as a center). Furthermore, absolute luminance when only optical fiber main body used in the examples 1 and 2 explained above was also measured as comparative examples.

Table 1 shown below indicates results of absolute luminance (cd/cm^2) measured based on above-explained method. In addition, attached Figure 5 shows distribution

diagram of relative luminance when maximum luminance of lights which exit from optical fiber or optical fiber main body based on the results measured shown in the Table 1 is identified as 100.

TABLE 1

	Distance from center				
	0 mm	50 mm	100 mm	150 mm	200 mm
example 1	5150	2900	1520	818	628
example 2	1930	1770	1230	804	631
comparative example	10200	6660	1300	607	471

note) The unit of numeral value shown above is cd/cm^2.

According to Figure 5, it was found that optical fibers of the example 1 and example 2 offer luminance independent of locations of measurement without reducing luminance in relative manner compared to that of the comparative example. In addition, the optical fiber of the example 2 was found to offer luminance that is independent of location of measurement without reducing luminance in relative manner compared to that of the example 1 due to the presence of light diffusion layer. And therefore, it became clear that these optical fibers by this invention enable uniform illumination on a display body over wide range with capability of controlling close arrangement.

In addition, difference between comparative example and each example was prominent even with visual observation. According to comparative example, difference in light and dark was clearly recognized at 50 mm away from the optical fiber as well as at the point that is further away. To this, difference in light and dark explained above could not be recognized in each example.

As explained above, according to this invention, it is possible to offer a display device that can carry out uniform illumination without close arrangement of optical fibers; and optical fibers of end-discharging type which are useful for the same.

What is claimed is:

1. A display device comprises a light source; at the least one optical fiber in which light from said light source is introduced at one end and are discharged from the other end; a light diverter that is arranged at said other end of said optical fiber and diverts light; and a display body that is irradiated by the light from said light diverter.

2. The display device according to the claim item 1, wherein a light diffuser is arranged on said light diverter.

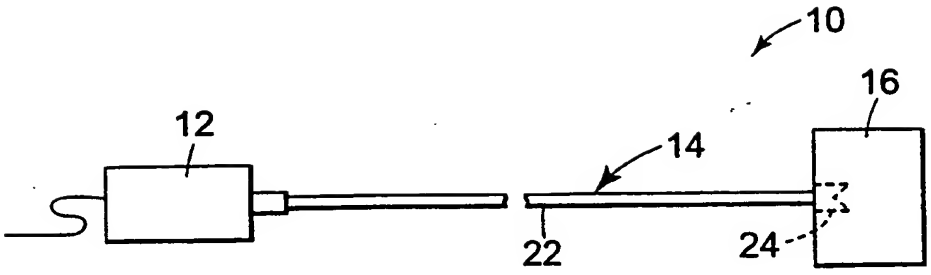

Fig. 1

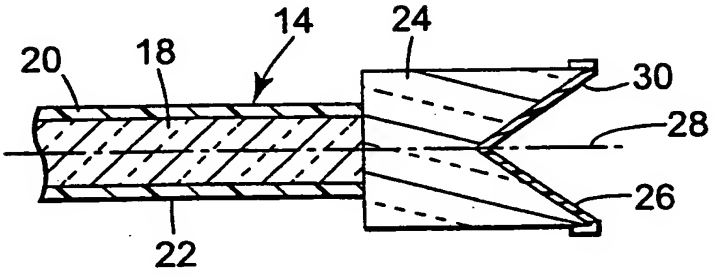

Fig. 2

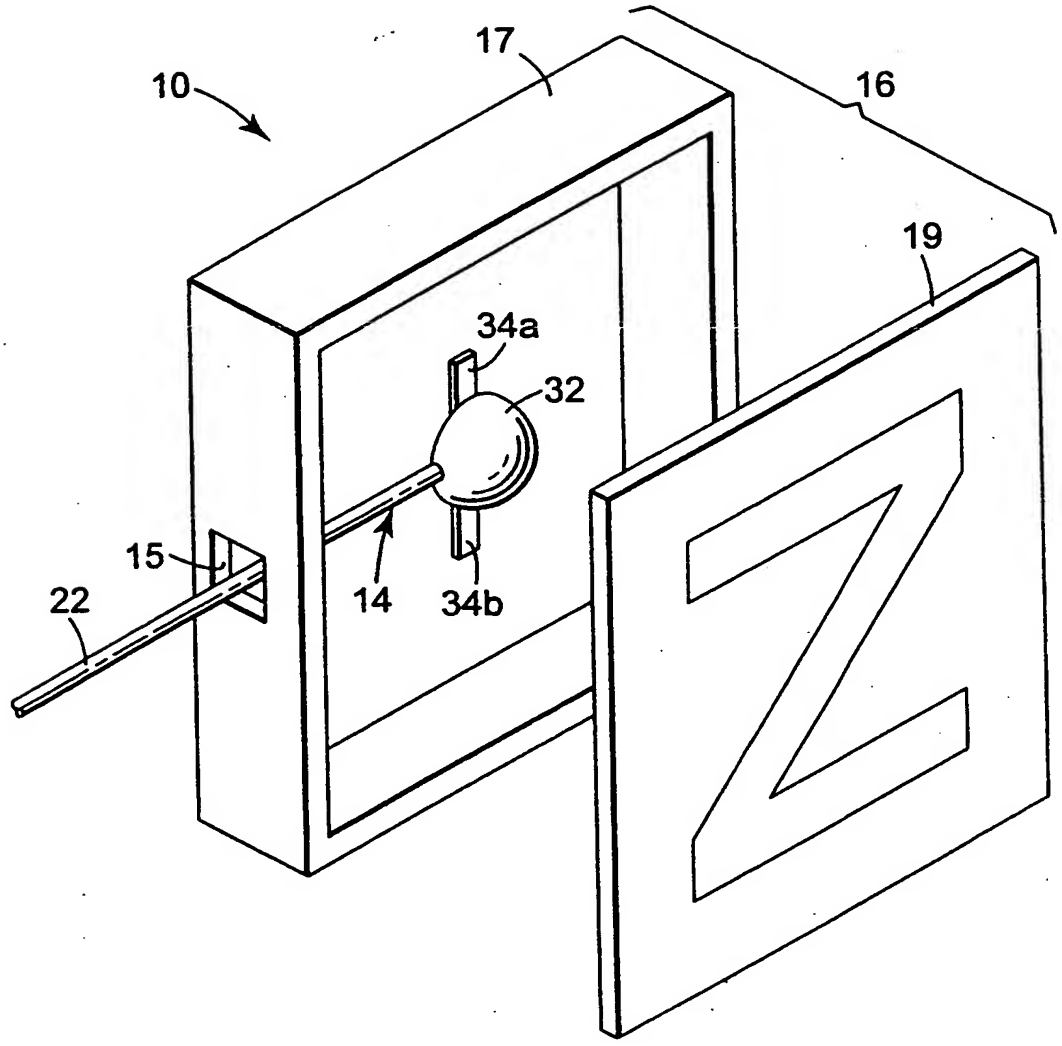

Fig. 3

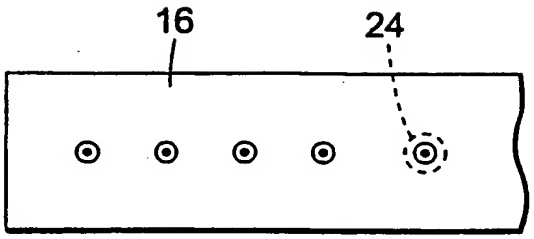
16
24

Fig. 4

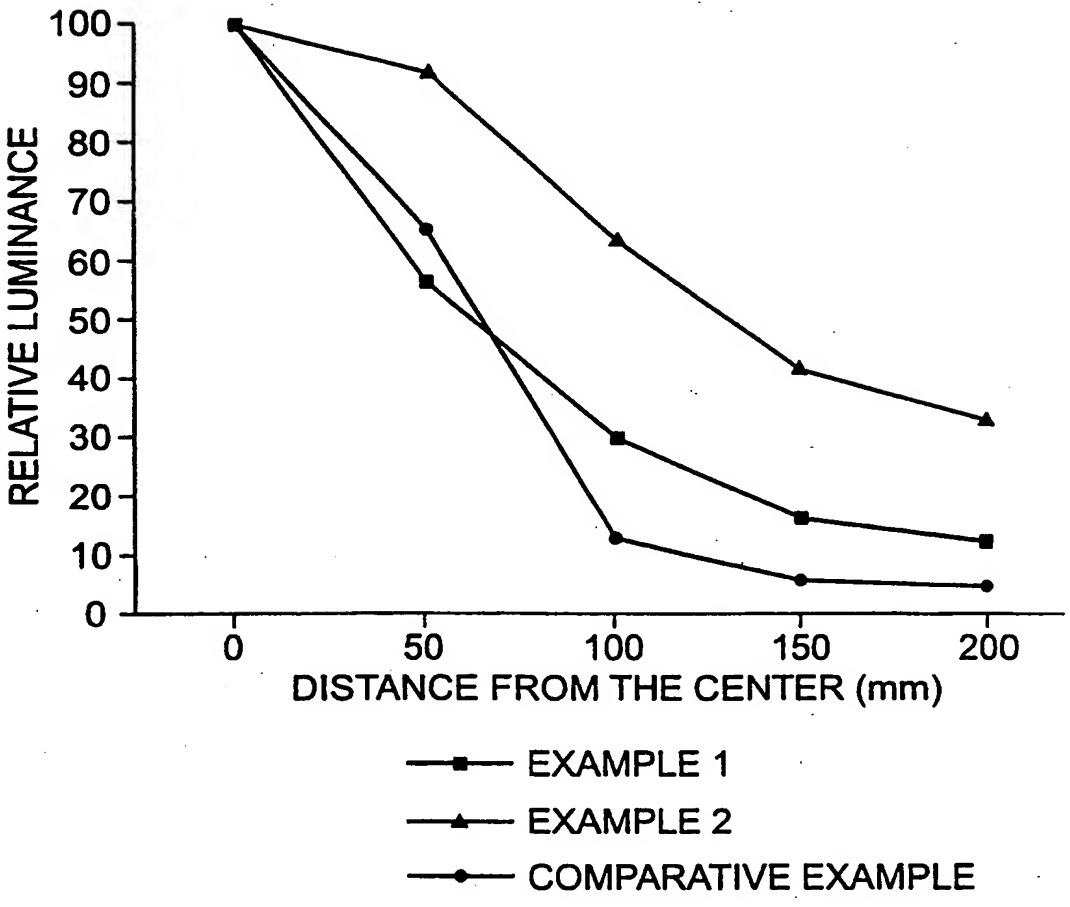
RELATIVE LUMINANCE
100
90
80
70
60
50
40
30
20
10
0
0
50
100
150
200
DISTANCE FROM THE CENTER (mm)
EXAMPLE 1
EXAMPLE 2
COMPARATIVE EXAMPLE

Fig. 5

INTERNATIONAL SEARCH REPORT

Int. ional Application No
PCT/US 99/15823

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F21V8/00

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	FR 2 174 380 A (L'EQUIPEMENT DE LA CONSTRUCTION ÉLECTRIQUE) 12 October 1973 (1973-10-12)	1,2
Y	page 3, line 29 - line 40; figure 1	1,2
Y	DE 195 38 868 A (GENERAL ELECTRIC) 2 May 1996 (1996-05-02) column 3 -column 4; figures 1-6	1,2

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19 October 1999	26/10/1999

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